AF / ZEW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of:	Uri Cohen		
Serial No.:	10/688,333	Filed:	Oct. 17, 2003
Examiner:	Wilkins III, Harry D.	Group Art Unit:	1753
Title:	Methods and Apparatus for Activating Openings and for Jets Plating		

SUBMISSION OF APPELLANT'S APPEAL BRIEF

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Sir:

Transmitted herewith is an Appeal Brief (with a check of $255.00).

Respectfully submitted,

Date: March 7, 2008

By Uri Cohen

Uri Cohen
(650) 494-0268
4147 Dake Avenue
Palo Alto, California 94306

Attached: an Appeal Brief (and a Fee of $255.00)

CERTIFICATE OF MAILING under 37 C.F.R. 1.8(a)

I hereby certify that this correspondence is being deposited on March 7, 2008 with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to Mail Stop Appeal Brief-Patents, Commissioner for Patents, P.O. 1450, Alexandria, Virginia 22313-1450.

Uri Cohen

March 7, 2007
Date of Signature

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BOARD OF PATENT APPEALS AND INTERFERENCES

Applicant:	**Uri Cohen**
Title:	**Methods and Apparatus for Activating Openings for Jets Plating**
Serial No.:	**10/688,333**
Filed:	**October 17, 2003**
Examiner:	**Wilkins III, Harry D.**
Group Art Unit:	**1753**
Date:	**March 7, 2008**

APPEAL BRIEF

CERTIFICATE OF MAILING under 37 C.F.R. 1.8(a)

I hereby certify that this correspondence is being deposited on March 7, 2008 with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to Mail Stop Appeal Brief-Patents, Commissioner for Patents, P.O. 1450, Alexandria, VA 22313-1450.

Uri Cohen

Uri Cohen

March 7, 2008

Date of Signature

Table of Contents

(1) Real Party in Interest.

The real party in interest is Uri Cohen, the inventor and owner of all right, title, and interest in and to the patent application. There has been no assignment.

(2) Related Appeals and Interferences.

There are no other pending appeals, interferences, or judicial proceedings known to Appellant (there is no assignee) which may be related to, or which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims.

Claims 1-10 and 29-43 are all the pending claims in the present patent application. Claims 1-10 and 29-43 stand rejected (Claims 1-10 have been rejected three times). Claims 1-10 and 29-43 are appealed.

(4) Status of Amendment.

No amendment was filed subsequent to the last rejection.

(5) Summary of the Claimed Subject Matter.

The technology covered by the various claims relates in general to electrochemical deposition (ECD) filling (or electrofilling) of a metal or an alloy inside deep and narrow openings located in a front surface of a substrate, and in particular, to activation methods aimed at improving electrolyte wetting and penetration inside the deep openings, prior to commencing electroplating. These methods are utilized directly (*in-situ*) in the electroplating solution (electrolyte). In some methods, an electrolyte wetting step is performed in the same (electroplating) chamber where a successive electroplating step is performed. In other methods, the electrolyte wetting step and the electroplating step may be performed in separate chambers. Each of the methods can be utilized alone, or in conjunction with one or more of the other methods described below.

In accordance with one embodiment of the invention, ultrasonic vibrations or, more preferably megasonic vibrations, are used in the activation (or wetting) solution to enhance wetting inside the deep openings. The wetting (or activation) solution is the same as the electroplating solution (electrolyte). The wetting solution may also include one or more wetting agents (surfactants) and an acid or other chemicals designed to remove surface oxides and/or surface contamination from the metallic surface. In a preferred embodiment, ultrasonic (or

preferably megasonic) vibrations are applied to the substrate in the electrolyte, in an activation-wetting step (prior to an electrofilling step), followed by an electrofilling step in the same electroplating chamber (with, or without, ultrasonic or megasonic vibrations).

The following briefly summarizes the invention of the various independent claims

Claim 1 relates to a method for electrofilling a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of: (a) immersing the substrate in an activation or wetting solution; (b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b): (c) applying high pressure jets of an electrolyte to the substrate, said electrolyte comprises metallic ions of said metal or alloy; and (d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening; wherein the activation or wetting solution is the same as the electrolyte, and wherein steps (a), (b), (c), and (d) are performed in the same chamber. Please refer to the specification at FIG. 1 in conjunction with paragraph [0055]. FIG. 1 shows a jets electrochemical deposition (JECD) tool appropriate for applying high pressure jets to a substrate surface during electroplating, and paragraph [0055] states:

> In accordance with a preferred embodiment of the invention, ultrasonic vibrations or, more preferably megasonic vibrations, can be used in-situ in the plating electrolyte during both the activation-wetting step prior to the electrofilling, and during the JECD electrofilling step. The ultrasonic or megasonic vibrations can be utilized in conjunction with jets plating in order to further enhance the electrolyte agitation. This embodiment is particularly advantageous for fast, reliable, and smooth electrofilling of very deep (10-100μm) and relatively wide (5-100μm) openings, such as vias and grooves used in 3-D and high density packaging.

Claim 29 relates to a method for electrofilling a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of: (a) immersing the substrate in an electrolyte contained in an electroplating chamber, said electrolyte comprising metallic ions of said metal or alloy; (b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b): (c) producing turbulent flow of the electrolyte at a surface of the substrate; and (d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening; wherein steps (a), (b), (c), and

(d) are performed in the electroplating chamber. Please refer to the specification at FIG. 1 in conjunction with paragraphs [0028] and [0055]. FIG. 1 shows a JECD tool appropriate for producing turbulent flow of the electrolyte at a surface of the substrate during electroplating, and paragraph [0028] states: "*Impinging powerful jets 36 create vigorous agitation and/or turbulent flow at the substrate's surface, thus facilitating enhanced replenishment in exposed areas.*" In addition, paragraph [0055] states:

> In accordance with a preferred embodiment of the invention, ultrasonic vibrations or, more preferably megasonic vibrations, can be used in-situ in the plating electrolyte during both the activation-wetting step prior to the electrofilling, and during the JECD electrofilling step. The ultrasonic or megasonic vibrations can be utilized in conjunction with jets plating in order to further enhance the electrolyte agitation. This embodiment is particularly advantageous for fast, reliable, and smooth electrofilling of very deep (10-100μm) and relatively wide (5-100μm) openings, such as vias and grooves used in 3-D and high density packaging.

Claim 39 relates to a method for electrofilling a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of: (a) immersing the substrate in an electrolyte, said electrolyte comprising metallic ions of said metal or alloy and at least one inhibitor additive; (b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b): (c) agitating the electrolyte across the front surface of the substrate; and (d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening; wherein inside surfaces of the at least one opening are wetted by utilizing steps (a) and (b) alone. Please refer to the specification at FIG. 1 in conjunction with paragraphs [0028] and [0055]. FIG. 1 shows a JECD tool appropriate for agitating the electrolyte across the front surface of a substrate during electroplating, and paragraph [0028] states: "*Impinging powerful jets 36 create vigorous agitation and/or turbulent flow at the substrate's surface, thus facilitating enhanced replenishment in exposed areas.*" In addition, paragraph [0055] states:

> In accordance with a preferred embodiment of the invention, ultrasonic vibrations or, more preferably megasonic vibrations, can be used in-situ in the plating electrolyte during both the activation-wetting step prior to the electrofilling, and during the JECD electrofilling step. The ultrasonic or megasonic vibrations can be utilized in conjunction with jets plating in order to further enhance the electrolyte agitation. This embodiment is particularly advantageous for fast, reliable, and smooth electrofilling of very

deep (10-100μm) and relatively wide (5-100μm) openings, such as vias and grooves used in 3-D and high density packaging.

(6) Grounds of Rejection to be Reviewed on Appeal.

1. Whether Claims 1, 3-5, and 29-32 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) with evidence from Zhao (US 6,071,809, for Claims 4-5 and 31-32 only).

2. Whether Claims 2, 7-9, 34-37 and 39-42 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) as applied to Claims 1 and 29, and further in view of Langner et al. (US 4,834,842) with evidence from Zhao (US 6,071,809, for Claims 8-9, 36-37, and 41-42 only).

3. Whether Claims 6 and 33 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes Jr. et al. (US 2002/0189637) as applied to Claims 1 and 29, and further in view of Reynolds (US 5,904,827).

4. Whether Claims 10 and 38 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) and Langner et al. (US 4,834,842) as applied to Claims 2 and 34, and further in view of Reynolds (US 5,904,827).

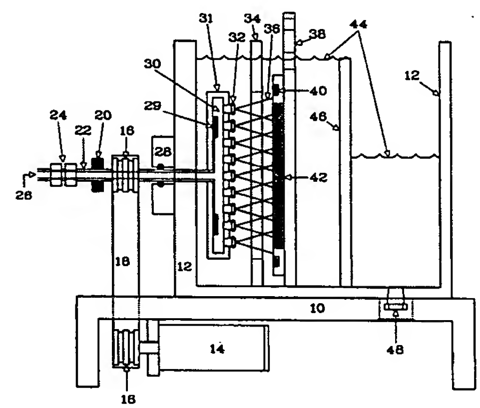
5. Whether Claim 43 is unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) and Langner et al. (US 4,834,842) as applied to Claims 39-42, and further in view of Reynolds (US 5,904,827).

(7) <u>Argument.</u>

<u>Issue 1</u>: **<u>Whether Claims 1, 3-5, and 29-32 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) with evidence from Zhao (US 6,071,809, for Claims 4-5 and 31-32 only).</u>**

<u>Section 1(A).</u> **<u>Not Obvious.</u>**

<u>Discussion of Tzanavaras et al.</u>



Tzanavaras et al. discloses a jets electrochemical deposition (JECD) tool (please refer to FIG. 1 displayed to the right; and col. 4, lines 25-68) that has: (a) <u>an electroplating chamber</u> (tank 12 in FIG. 1); (b) <u>a rotating anodes/jets assembly</u> (RAJA 30 in FIG. 1); (c) <u>a substrate (cathode)</u> (numeral 42 in FIG. 1); (d) <u>electrolyte</u> (numerals 26, 44 in FIG. 1); (e) <u>jet nozzles</u> (numeral 32 in FIG. 1); and (f) when operating, <u>electrolyte jets</u> (numeral 36 in FIG. 1). Tzanavaras et al. teaches (at col. 3, lines 9-22):

> The RAJA and the cathode (or substrate) are placed in the electrolyte in close proximity and facing each other, thereby providing high pressure jets of the electrolyte in a direction essentially normal to the substrate's surface. The impinging powerful jets create turbulent flow at the substrate's surface, thus providing efficient agitation and replenishment in all areas, including complex mask features with varying depth and opening sizes. High aspect ratio opening areas receive a similar degree of agitation (and replenishment) as areas of lower aspect ratios. Even features with the deepest and smallest openings (having the highest aspect ratio) receive essentially the same degree of agitation as areas of lower aspect ratios.

Tzanavaras et al. further discloses (at col. 1, lines 34-38) that the width of the openings may vary between about 5-7μm to about 50-75μm.

Thus, a person of ordinary skill in the art ("POSITA"), upon reading Tzanavaras et al., would understand that powerful jets <u>alone</u> provide efficient agitation (and, therefore, full electrolyte wetting) <u>inside openings</u>, <u>and *most important*,</u> <u>inside the deepest and smallest openings having the highest aspect ratios</u>.

Discussion of Downes et al.

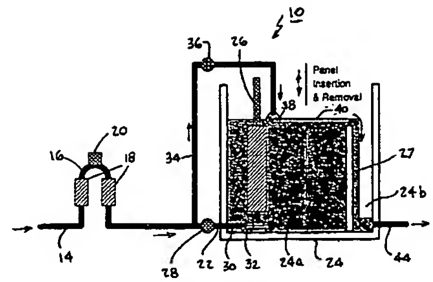


FIG. 1

Downes et al. discloses (please refer to FIG. 1 displayed to the right; and the Abstract) a method for degassing small, high aspect ratio, drilled holes or vias in printed circuit boards prior to electroless copper plating --the degassing is intended to remove air or gas bubbles from the holes or vias which tend to inhibit electroless plating. In particular, Downes et al. teaches one method for degassing that entails: (a) degassing a liquid, and then, (b) ultrasonically prewetting printed circuit boards in a bath of the degassed liquid. Downes et al. discloses (in FIG. 1; and at paragraphs [0034]-[0038]) that degassing apparatus **10** includes: (a) conduit **14** (for incoming liquid such as deionized water, liquid/surfactants, caustic solutions or the like) having loop portion **16** with one or more ultrasonic degassing units **18** installed therein; and (b) prewetting bath tank **24** (incorporating ultrasonic energy sender array **26)** downstream form ultrasonic degassing units **18**. In use, printed circuit board panel **12** (obscured in FIG. 1) is inserted or removed from tank **24** through the top surface of the prewetting liquid bath. Downes et al. also teaches (see the Abstract and paragraphs [0022], [0025], [0039]-[0041]) that the liquid in the prewetting bath is different from the plating solution, and that the prewetting chamber (i.e., prewetting bath tank **24**) is different from the plating chamber.

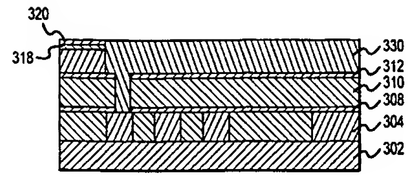
Notably, Downes et al. (see paragraphs [0024], [0042]) teaches that removal of air or gas bubbles is easier in low aspect ratio holes or vias than in high aspect ratio holes or vias. Specifically, Downes et al. teaches (at paragraph [0042]):

> In the event that the holes are small diameter sized with only small aspect ratios, rather than employing the ultrasonic sender array **26** in the prewetting tank **24**, it may be adequate to simply employ mechanical vibration or agitation in the fully degassed tank **24** such as through well-known mechanical devices in order to dissolve all of the residual air bubbles remaining in the liquid or water and in the holes and allow them to discharge through the drain **44**.

Thus, Downes et al. teaches that ultrasonic vibrations to the substrate may not be necessary for prewetting holes or vias having low aspect ratios.

Discussion of Zhao

Zhao discloses (please refer to FIG. 3J to the right; and col. 7, line 36 through col. 8, line 14) dual damascene methods and structures for IC interconnects. Zhao discloses a bulk metal **330** connected through a via to a lower level conductor **304**. Zhao further discloses that bulk metal **330** can be deposited by electroplating or by a CVD method. Zhao discloses (at col. 7, lines 55-67) a barrier layer and a Cu seed layer (not shown) deposited prior to forming bulk copper layer **330** by electroplating.



Discussion of combinations of Tzanavaras et al., Downes et al., and Zhao

(1) The Examiner rejected Claims 1, 3-5, and 29-32 over Tzanavaras et al. in view of Downes et al. However, the Examiner made an improper presumption based solely on impermissible hindsight when he asserted:

> [i]t would have been obvious to one of ordinary skill in the art to have applied, prior to commencement of electroplating in the process of Tzanavaras et al ultrasonic or megasonic vibrations to the substrate of Tzanavaras et al for the known purposes of ensuring adequate wetting of openings in the surface of the substrate in the size range of 25.4-50.8 microns.

The Examiner's assertion completely ignores the teaching of Tzanavaras et al. (at col. 3, lines 13-22) that <u>electrolyte jets alone provide efficient agitation and, therefore, full wetting inside all openings</u>:

> The impinging powerful jets create turbulent flow at the substrate's surface, thus providing efficient agitation and replenishment in all areas, including complex mask features with varying depth and opening sizes. High aspect ratio opening areas receive a similar degree of agitation (and replenishment) as areas of lower aspect ratios. Even features with the deepest and smallest openings (having the highest aspect ratio) receive essentially the same degree of agitation as areas of lower aspect ratios.

And, at col. 3, lines 24-34:

> Each mask opening on the (stationary) substrate is subject to periodic pulsating jets produced by the RAJA. This pulsating action allows for pressure relaxation and outflow of depleted solution from the opening during periods when the jets are away. During periods when the jets are impinging on the openings, fresh solution is injected into the openings. The

> turbulent flow and pulsating action prevent the formation of stagnant (and depleted) electrolyte solution in deep and narrow mask openings.

Tzanavaras et al. further discloses (at col. 1, lines 34-38) that the width of the openings may vary between about 5-75μm (<u>note</u> that this range of Tzanavaras et al. covers the range of Downes et al. of about 25.4-50.8μm).

Therefore, a POSITA, upon reading Tzanavaras et al., would understand that high pressure electrolyte jets alone provide full wetting inside all openings. For further clarification, the following scenario should be helpful. Upon reading Tzanavaras et al., a POSITA might be motivated to use high pressure electrolyte jets for electrofilling deep openings. Reading then Downes et al., the POSITA would become aware of a wetting problem inside openings (when high pressure electrolyte jets are not used). The POSITA would then refer back to Tzanavaras et al., to check how Tzanavaras et al. deals with this issue. The POSITA would then be assured by Tzanavaras et al. that the high pressure electrolyte jets <u>alone</u> provide <u>full wetting inside all openings</u>, including the narrowest and highest aspect ratio openings. As such, the POSITA <u>would have no motivation, whatsoever</u>, to combine Tzanavaras et al. with Downes et al., because the POSITA would fully understand that Downes et al.'s ultrasonic or megasonic prewetting step would be superfluous. In fact, the POSITA would understand that Downes et al.'s ultrasonic or megasonic prewetting step, <u>at best</u>, could only provide functionality that was already present in Tzanavaras et al. Appellant submits that no one would add a process step to an existing process (and, thereby significantly increase equipment complication, process time, and cost) if there were no functional benefit. Hence, in view of the above, Appellant submits that the Examiner's rejection is based on an impermissible hindsight because it merely uses the language of Claims 1 and 29 as a roadmap.

(2) In response to the Office Action of 1/25/2007, claims 1, 3-5, and 29-32 were amended to require that "*the activation or wetting solution is the same as the electrolyte.*" In that Office Action (of 1/25/2007) the Examiner stated (see pg. 2):

> 2. Applicant's remarks with respect to at least claims 4 and 9 [claims 4 and 9 required the activation or wetting solution to be the same as the electrolyte] with respect to a lack of motivation from Downes, Jr. et al to perform the wetting and electroplating steps with the same solution is found persuasive and the rejection grounds of claims 4 and 9 utilizing Downes, Jr. et al have been withdrawn.

As set forth in detail below, and as the Examiner agreed, Downes et al. teaches away from having the activation or wetting solution be the same as the electrolyte. As such, it is improper to combine Tzanavaras et al. with Downes et al. to meet the limitations of Claims 1, 3-5, and 29-32.

In sum, a POSITA <u>would have no motivation</u> to combine Tzanavaras et al. and Downes et al. In fact, as discussed above, a POSITA would have a substantial disincentive to combine the references, either because (a) Downes et al. does not add any functionality to that already provided by Tzanavaras et al., while adding to the cost and complexity of the apparatus and method, or (b) as discussed in more detail in **Section 1(B)** below, Downes et al. teaches away from having the activation or wetting solution be the same as the electrolyte. Lastly, as discussed in more detail in **Section 1(B)** below, Tzanavaras et al. teaches away from using an ultrasonic or megasonic prewetting step. Thus, because both of these references teach away from essential elements of Claims 1, 3-5, and 29-32, it is improper to combine them to meet the limitations of Claims 1, 3-5, and 29-32.

<u>Claims 4-5 and 31-32</u>: Appellant submits that Claims 4-5 depend from patentable Claim 1, and Claims 31-32 depend from patentable Claim 29, and are, therefore, patentable over Tzanavaras et al. in view of Downes et al., for at least the reasons set forth above (and below), for Claims 1 and 29. Zhao is merely (purportedly) relevant to the further limitations of: "*wherein the at least one opening has a sidewall surface comprising an exposed metallic surface*" in Claims 4 and 31, and "*wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface*" in Claims 5 and 32. As such, Zhao's disclosure, of dual damascene structures with barrier and seed layers, has no effect on the arguments set forth above (and below) regarding Tzanavaras et al. in view of Downes et al. The addition of Zhao does not affect, whatsoever, the allowability of claims 1 and 29. Therefore, Appellant respectfully submits that claims 4-5 and 31-32 are also patentable over Tzanavaras et al. in view of Downes et al. and further in view of Zhao.

<u>Claims 1, 3-5, and 29-32 are Not Obvious Because They Provide Unpredictable Results</u>

The Supreme Court case of <u>KSR Int'l Co. v. Teleflex Inc.</u>, 127 S.Ct. 1727, 82 USPQ2d 1385 (2007) set forth legal principles regarding obviousness rejections. The following are two of

the relevant legal principles from that case, and a discussion of how they are applicable to **Issue 1**.

First legal principle: In quoting United States v. Adams, 383 U. S. 39, 40 (1966), the Supreme Court in KSR stated "*The Court recognized that when a patent claims a structure already known in the prior art that is altered by the mere substitution of one element for another known in the field, the combination must do more than yield a predictable result.*" This first legal principle is especially relevant to the present application where, as discussed in more detail in **Section (1C)** below, Appellant discovered that: (a) contrary to the teaching of Tzanavaras et al., the application of high pressure electrolyte jets alone is insufficient for full wetting inside deep openings; (b) contrary to the teachings of Downes et al. and Tzanavaras et al., insufficient electrolyte wetting is more prevalent inside wider openings than inside narrower openings (a newly discovered wetting problem); and (c) the source of the newly discovered wetting problem (that electrolyte wetting inside wider openings is more difficult than inside narrower openings) is due to smaller capillary forces inside wider openings than inside narrower openings. These discoveries are unpredictable because: (a) the prior art (see Tzanavaras et al., col. 3, lines 13-22, 24-34) teaches that electrolyte jets alone can accomplish full wetting inside all openings (including the smallest, deepest, and highest aspect ratio openings); and (b) the prior art teach (see Downes et al. at paragraphs [0024], [0042]; and Tzanavaras et al. at col. 3, lines 17-22) that insufficient wetting problem is more prevalent inside narrower (higher aspect ratio) openings than inside wider (lower aspect ratio) openings. Thus, the unpredictable results produced by Appellant's discoveries render Claims 1, 3-5, and 29-32 nonobvious and patentable.

In addition to the above, MPEP 2141.02, Section III states that the discovery of the source of a problem should be considered as part of "As a Whole" inquiry: "*[A] patentable invention may lie in the discovery of the source of a problem even though the remedy may be obvious once the source of the problem is identified. This is part of the 'subject matter as a whole' which should always be considered in determining the obviousness of an invention under 35 U.S.C. § 103.*" As set forth above and in more detail in **Section 1(C)** below, Appellant has discovered a new problem, and the source of the new problem. Therefore, in accordance with MPEP 2141.02, Section III, even though the remedy to the newly discovered problem may be obvious once the source of the problem has been identified, Appellant's discoveries render Claims 1, 3-5, and 29-32 nonobvious and patentable.

<u>Second legal principle</u>: In quoting <u>United States v. Adams, 383 U. S. 39, 50-51 (1966)</u>, the Supreme Court in <u>KSR</u> stated "*The Court relied upon the corollary principle that when the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious.*" This second legal principle is especially relevant to Claims 1, 3-5, and 29-32 of the present application, where (as set forth in more detail in **Section 1(B)** below) Tzanavaras et al. teaches away from an essential element of Claims 1, 3-5, and 29-32, and Downes et al. teaches away from other essential elements of Claims 1, 3-5, and 29-32. Specifically, Claims 1, 3-5, and 29-32 require an ultrasonic or megasonic electrolyte wetting step, prior to commencing the electroplating step. In contrast, Tzanavaras et al. teaches (at col. 3, lines 13-22) that electrolyte jets <u>alone</u> accomplish efficient agitation (and hence full electrolyte penetration and wetting) <u>inside all openings</u>, including wide and narrow, and low and high aspect ratio openings. Also, Downes et al. teaches (at paragraphs [0022], [0028], [0031], [0033], [0040]) to use a different pre-wetting solution than the plating solution, and to perform the pre-wetting step in a separate chamber than the plating chamber. In contrast, Claims 1, 3-5, and 29-32 require that the wetting solution is the same as the electrolyte, and that all the steps, including the ultrasonic or megasonic wetting step, and the electroplating step, be performed in the same (electroplating) chamber. Because both Tzanavaras et al. and Downes et al. teach away from essential elements of Claims 1, 3-5, and 29-32, these references cannot be properly combined with each other, or with any other reference, including Zhao, to meet the limitations of Claims 1, 3-5, and 29-32. Therefore, Claims 1, 3-5, and 29-32 are nonobvious.

<u>Section 1(B).</u> <u>Tzanavaras et al. and Downes et al. Teach Away from Essential Elements of Claims 1, 3-5, and 29-32.</u>

In evaluating obviousness, it is not proper to selectively consider only part of a reference while ignoring other parts that teach away from the invention. In this regard, MPEP §2141.02 specifies that:

> "A prior art reference must be considered in its entirety, i.e., as a <u>whole</u>, including portions that would lead away from the claimed invention." [Emphasis added in original].

Also,

> As set forth in <u>Ormco Corp. v. Align Technology Inc.</u>, 463 F3d 1299 [79 USPQ2d 1931] (Fed. Cir. 2006) at 1940: However, a reference that "teaches away" from a given combination may negate a motivation to modify the prior art to meet the claimed invention. See, e.g., *Medichem, S.A. v. Rolabo,*

> S.L., 437 F.3d 1157, 1165 [77 USPQ2d 1865] (Fed. Cir. 2006). 'A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant.' *In re Kahn*, 441 F.3d at 990 (quoting *In re Gurley*, 27 F.3d 551, 553 [31 USPQ2d 1130] (Fed. Cir. 1994)) (internal quotation marks omitted).

Appellant submits that both Tzanavaras et al. and Downes et al. teach away from essential elements of Claims 1, 3-5, and 29-32. Specifically, Claims 1, 3-5, and 29-32 require "*applying ultrasonic or megasonic vibrations to the substrate, and after commencing step (b): ... applying an electroplating current ...* ." Tzanavaras et al. teaches away from this essential element of Claims 1, 3-5, and 29-32 by teaching that electrolyte jets <u>alone</u> accomplish efficient agitation (and hence full electrolyte wetting) <u>inside all openings</u>, including wide and narrow, and high and low aspect ratio openings. For example, Tzanavaras et al. teaches at col. 3, lines 13-22:

> The impinging powerful jets create turbulent flow at the substrate's surface, thus providing efficient agitation and replenishment in all areas, including complex mask features with varying depth and opening sizes. High aspect ratio opening areas receive a similar degree of agitation (and replenishment) as areas of lower aspect ratios. Even features with the deepest and smallest openings (having the highest aspect ratio) receive essentially the same degree of agitation as areas of lower aspect ratios.

And, at col. 3, lines 24-34:

> Each mask opening on the (stationary) substrate is subject to periodic pulsating jets produced by the RAJA. This pulsating action allows for pressure relaxation and outflow of depleted solution from the opening during periods when the jets are away. During periods when the jets are impinging on the openings, fresh solution is injected into the openings. The turbulent flow and pulsating action prevent the formation of stagnant (and depleted) electrolyte solution in deep and narrow mask openings.

Tzanavaras et al. further discloses (at col. 1, lines 34-38) that the width of the openings may vary between about 5-75μm (which includes Downes et al.'s range of about 25.4-50.8μm).

Therefore, Tzanavaras et al. teaches away from an essential element of Claims 1, 3-5, and 29-32 because, upon reading Tzanavaras et al., a POSITA would be led in a direction divergent from the path that was taken by the Appellant, that path being to provide an ultrasonic or megasonic wetting step prior to jets electroplating.

Claims 1, 3-5, and 29-32 also require "*wherein the activation or wetting solution is the same as the electrolyte, and wherein steps (a), (b), (c), and (d) are performed in the same*

chamber." Downes et al. teaches away from these essential elements of Claims 1, 3-5, and 29-32 by teaching (at paragraphs [0022], [0028], [0031], [0033], [0040]) to use a different pre-wetting solution than the plating solution, and to perform the prewetting step in a separate chamber than the plating chamber. For example, Downes et al. teaches at paragraph [0022]:

> The continuous water exchange and flow of the liquid ... thus imparting a further cleaning function to the pre-wetting process. This, in effect, will prevent any drying or dewetting of the articles prior to subsequent electroless copper plating.

And, at paragraph [0040]:

> Upon completion of the prewetting process, which maybe a first step preceding an electroless copper plating or precleaning process sequence, the panels may be conveyed to a subsequent process tank (not shown) whereby typical tank-to-tank transfers may entail a period of time of 1 to 2 minutes. Within this time frame, it would be rather difficult to dewet the already wetted vias or holes which have a capillary-like wetted surfaces preparing these for subsequent cleaning and electroless copper plating.

Therefore, Downes et al. teaches away from essential elements of Claims 1, 3-5, and 29-32 because, upon reading Downes et al., a POSITA would be led in a direction divergent from the path that was taken by the Appellant, that path being to combine ultrasonic or megasonic electrolyte wetting with jets electroplating in the same chamber, and using the same activation or wetting solution as the electrolyte.

Therefore, because both Tzanavaras et al. and Downes et al. teach away from essential elements of Claims 1, 3-5, and 29-32, these references <u>cannot be properly</u> combined with each other, or with <u>any</u> other reference, including Zhao, to meet the limitations of Claims 1, 3-5, and 29-32. As such, Claims 1, 3-5, and 29-32 are nonobvious.

<u>Section 1(C).</u> <u>Appellant's Unpredictable and Unexpected Discoveries Render Claims 1, 3-5, and 29-32 to be Nonobvious.</u>

In accordance with MPEP 2141.02, Section III, the discovery of the source or cause of a problem should be considered as part of 'As a Whole' inquiry: "*[A] patentable invention may lie in the discovery of the source of a problem even though the remedy may be obvious once the source of the problem is identified. This is part of the 'subject matter as a whole' which should always be considered in determining the obviousness of an invention under 35 U.S.C. § 103.*" In re Sponnoble, 405 F.2d 578, 585, 160 USPQ 237, 243 (CCPA 1969).

Appellant discovered that: (a) contrary to the teaching of Tzanavaras et al., that application of high pressure electrolyte jets alone is insufficient for full wetting inside deep openings; (b) contrary to the teachings of Downes et al. and Tzanavaras et al., that insufficient electrolyte wetting is more prevalent inside wider openings than inside narrower openings (a newly discovered wetting problem); and (c) the source of the newly discovered wetting problem (that electrolyte wetting inside wider openings is more difficult than inside narrower openings) is due to smaller capillary forces inside wider openings than inside narrower openings. These discoveries are unpredictable because: (a) the prior art (see Tzanavaras et al., col. 3, lines 13-22, 24-34) teaches that electrolyte jets alone can accomplish full wetting inside all openings (including the smallest, deepest, and highest aspect ratio openings); and (b) the prior art (see Downes et al. at paragraphs [0024], [0042]; and Tzanavaras et al. at col. 3, lines 17-22) that insufficient wetting problem is more prevalent inside narrower openings than inside wider openings.

As evidence of the newly discovered problem, Appellant has attached below (see Evidence Appendix, pp. B1-B6) his Declaration, which was originally filed on December 19, 2006. Columns 2 (Via Width), 5 (Wetted Depth), and 6 (Wetted Depth Fraction) of Table **I** (see Evidence Appendix, pg. B3), and related Figures 2A-2D (in Exhibit A; see Evidence Appendix pp. B5-B6) demonstrate Appellant's surprising and unexpected discoveries: (a) that high pressure electrolyte jets alone are insufficient for full wetting inside deep openings, and (b) that the insufficient electrolyte wetting problem becomes more prevalent with increasing width of the deep openings. Using high pressure electrolyte jets alone (with no ultrasonic or megasonic prewetting step), resulted in electrolyte wetting depth (or penetration) close to 100% inside 6μm wide vias, but was only about 48% inside 55μm wide vias. In other words, the wider (and lower aspect ratio) openings had a more severe electrolyte wetting problem than the narrower (and higher aspect ratio) openings. Appellant has further discovered that the source of that problem was due to diminishing capillary forces with increasing width of the openings. See, for example, paragraph [0013] of the specification of the invention:

> Inadequate electrolyte wetting problems are particularly problematic in relatively wide, but very deep openings. In particular, wetting is difficult inside openings with depth in the range of about 5-100μm and width in the range of about 5-200μm. Such openings are frequently used in 3-D wafer packaging (for contacts through the wafer), in chip-scale packaging (CSP), wafer-scale packaging (WSP), TFH, MEMS, and systems on chip (SOC).

> They are prone to insufficient or inadequate electrolyte wetting. For example, vias of such dimensions in 3-D packaging may require several hours of immersion in the electrolyte, for its complete penetration into the vias to wet and plate the lower sidewalls and bottom of the vias. As the width of the openings decreases, capillary forces become stronger, thus improving the wetting. As a result, narrower openings wet better and faster than wider openings of the same depth. For this reason, wetting problems are less prevalent in submicron openings, used in VLSI and ULSI copper interconnects (having width of about 0.1-0.5μm and depth of about 0.5-1.5μm), than in the much wider (≥ 5μm) and deeper (≥ 10μm) openings encountered in packaging.

In contrast, the prior art references assert that the wetting problem is more prevalent in narrower (and higher aspect ratio) openings than in wider (and lower aspect ratio) openings. For example, Tzanavaras et al. asserts at col. 3, lines 17-22:

> High aspect ratio opening areas receive a similar degree of agitation (and replenishment) as areas of lower aspect ratios. Even features with the deepest and smallest openings (having the highest aspect ratio) receive essentially the same degree of agitation as areas of lower aspect ratios.

Similarly, Downes et al. asserts at paragraphs [0024] and [0042] that removal of air or gas bubbles is easier in low aspect ratio holes or vias than in high aspect ratio holes or vias. Downes et al. teaches in paragraph [0024]:

> Although so-called panel bumping and panel tilting have been employed in the technology in order to remove air from drilled holes prior to and/or during the plating processes, this maybe somewhat effective for larger-sized holes or vias, but remains essentially ineffective for smaller holes or vias, particularly those possessing high-aspect ratios.

And, in paragraph [0042]:

> In the event that the holes are small diameter sized with only small aspect ratios, rather than employing the ultrasonic sender array **26** in the prewetting tank **24**, it may be adequate to simply employ mechanical vibration or agitation in the fully degassed tank **24** such as through well-known mechanical devices in order to dissolve all of the residual air bubbles remaining in the liquid or water and in the holes and allow them to discharge through the drain **44**.

In effect, Downes et al. teaches that ultrasonic vibrations to the substrate may not be necessary for prewetting holes or vias having low aspect ratios.

Therefore, in accordance with MPEP 2141.02, Section III, even though the remedy to the newly discovered problem may be obvious once the source of the problem has been identified, Appellant's discoveries render Claims 1, 3-5, and 29-32 nonobvious and patentable.

Issue 2: **Whether Claims 2, 7-9, 34-37 and 39-42 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) as applied to Claims 1 and 29, and further in view of Langner et al. (US 4,834,842) with evidence from Zhao (US 6,071,809, for Claims 8-9, 36-37, and 41-42 only).**

Discussion of Langner et al.

Langner et al. discloses (at the Abstract and col. 5, lines 1-63) a method for measuring inhibitor concentration in electrolytes, including copper electrolytes.

Discussion of the combination of Tzanavaras et al., Downes et al., Langner et al, and Zhao

Please see a discussion of the combination of Tzanavaras et al., Downes et al., and Zhao in **Section 1(A)** above.

Claims 2, 7-9, and 34-37.

Appellant hereby repeats and incorporates his arguments set forth above in **Issue 1 (Sections 1(A)-1(C))** regarding Claims 1, 3-5, and 29-32. Appellant respectfully submits that Claims 2, 7-9 depend from patentable Claim 1, and Claims 34-37 depend from patentable Claim 29, and are thus patentable over Tzanavaras et al. in view of Downes et al. and Zhao for at least the same reasons discussed in **Issue 1** above.

Langner et al. is merely (purportedly) relevant to the further limitation in Claims 2, 7-9, and 34-37: "*wherein the electrolyte comprises at least one inhibitor additive.*" As such, the disclosure of Langner et al. has no effect on the arguments set forth above regarding Tzanavaras et al. in view of Downes et al. and Zhao. Furthermore, Langner et al. does not suggest or hint the use of an ultrasonic or megasonic wetting step in the electrolyte, required by Claims 2, 7-9, and 34-37 of the invention.

Therefore, neither Tzanavaras et al., nor Downes et al, nor Langner et al., nor Zhao, nor any proper combination thereof, discloses or suggests the methods of Claims 1 and 29 with the further limitation that the electrolyte comprises at least one inhibitor additive, as recited in Claims 2, 7-9, and 34-37. In light of the above, Appellant respectfully submits that Claims 2, 7-9, and 34-37 are patentable over Tzanavaras et al. in view of Downes et al., and further in view of Langner et al. and Zhao.

Claims 39-42.

Appellant hereby repeats and incorporates his arguments set forth in **Issue 1** and Claims 2, 7-9, and 34-37 above. Appellant respectfully submits that independent Claim 39 is similar to independent Claims 1 and 29, except that: (i) Claim 39 does not require that all the steps be performed in the electroplating chamber; (ii) Claim 39 recites a further limitation that the wetting is accomplished solely by immersing the substrate in the electrolyte (step (a)), and applying ultrasonic or megasonic vibrations to the substrate (step (b)); and (iii) Claim 39 recites a further limitation that the electrolyte comprises at least one inhibitor additive.

In his latest Office Action (of 09/05/2007) the Examiner rejected Claim 39 on the same grounds that he rejected Claims 1, and 29. Namely, as being obvious over Tzanavaras et al. in view of Downes et al. The Examiner stated (on pg. 5): "*The teachings of Tzanavaras et al and Downes, Jr. et al. are described above.*" And (on pg. 6): "*Regarding Claim 39, as above, the combination of Tzanavaras et al with Downes, Jr. et al teaches one of ordinary skill in the art to perform the wetting of the substrate within a single cell by immersing the substrate in an electrolyte and applying ultrasonic or megasonic vibrations.*" In response, Appellant repeats his arguments set forth above in **Issue 1 (Sections 1(A)-1(C))** regarding Claims 1, 3-5, and 29-32. Appellant respectfully submits that Claim 39 is patentable over Tzanavaras et al. in view of Downes et al., for the same reasons that Claims 1 and 29 are patentable over these references, as was set forth above in **Issue 1**. Furthermore, the addition of Langner et al. has no effect on the patentability of Claim 39, because Langner et al. is merely (purportedly) relevant to the further limitation in Claims 39: "*said electrolyte comprising metallic ions of said metal or alloy and at least one inhibitor additive.*" As such, the disclosure of Langner et al. has no effect on the arguments set forth above regarding Tzanavaras et al. in view of Downes et al. Furthermore, Langner et al. does not suggest or hint the use of an ultrasonic or megasonic wetting step in the electrolyte, as required by Claims 39 of the invention.

Therefore, neither Tzanavaras et al., nor Downes et al, nor Langner et al., nor Zhao, nor any proper combination thereof, discloses or suggests the method of Claims 39. In light of the above, Appellant respectfully submits that Claim 39 is patentable over Tzanavaras et al. in view of Downes et al., and further in view of Langner et al. and Zhao.

Furthermore, Appellant respectfully submits that Claims 40-42 depend from patentable Claim 39, and are, therefore, also patentable over Tzanavaras et al. in view of Downes et al., and

further in view of Langner et al. and Zhao, for at least the same reasons set forth above for Claim 39.

<u>Conclusion</u>:

In view of all of the above, Applicant respectfully submits that Claims 2, 7-9, 34-37, and 39-42 are nonobvious and patentable over Tzanavaras et al. in view of Downes et al., and further in view of Langner et al. and Zhao.

Issue 3: **<u>Whether Claims 6 and 33 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes Jr. et al. (US 2002/0189637) as applied to Claims 1 and 29, and further in view of Reynolds (US 5,904,827).</u>**

<u>Discussion of Reynolds</u>

Reynolds discloses (at FIG. 3; Abstract; and col. 7, line 62 through col. 8, line 30) a fluid powered rotary blade electroplating cell with a megasonic transducer **90**. Reynolds teaches application of megasonic vibrations <u>during the electroplating</u>. For example, Reynolds teaches at col. 1, lines 20-23: "*The invention is more specifically directed to a plating cell in which a fluid powered rotary wiper, in combination with the megasonic action of the transducer, ensures efficient and uniform plating.*" And, at col. 5, lines 3-5: "*The combination of rotary blade and megasonic agitation avoids regions of dead flow and ensures uniformity of the metallization thickness and uniformity.*" However, Reynolds <u>does not teach or suggest</u> an ultrasonic or <u>megasonic prewetting step</u>, prior to the electroplating step.

<u>Discussion of the combination of Tzanavaras et al., Downes et al., and Reynolds et al.</u>

Please see a discussion of the combination of Tzanavaras et al. and Downes et al., in **Section 1(A)** above.

Appellant hereby repeats and incorporates his arguments set forth above in **Issue 1 (Sections 1(A)-1(C))** regarding Claims 1, 3-5, and 29-32. Appellant respectfully submits that Claim 6 depends from patentable Claim 1, and Claim 33 depends from patentable Claim 29, and thus Claims 6 and 33 are patentable over Tzanavaras et al. in view of Downes et al., for at least the same reasons discussed in **Issue 1** above.

Furthermore, Reynolds et al. is merely (purportedly) relevant to the further limitation in Claims 6 and 33 of continuing the ultrasonic or megasonic vibrations to the substrate during at least a portion of the electroplating step: "*wherein step (b) is continued during at least a portion of steps (c) and (d).*" As such, the disclosure of Reynolds et al. has no effect on the arguments set forth above regarding Tzanavaras et al. in view of Downes et al. Furthermore, Reynolds et al. does not teach or suggest using an ultrasonic or megasonic prewetting step, as required by Claims 6 and 33 of the invention.

Therefore, neither Tzanavaras et al., nor Downes et al, nor Reynolds et al., nor any proper combination thereof, discloses or suggests the methods of Claims 1 and 29 with the further

limitation that the ultrasonic or megasonic vibrations to the substrate are continued during at least a portion of the duration of the electroplating step, as recited in Claims 6 and 33. In light of the above, Appellant respectfully submits that Claims 6 and 33 are patentable over Tzanavaras et al. in view of Downes et al., and further in view of Reynolds et al.

Issue 4: **Whether Claims 10 and 38 are unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) and Langner et al. (US 4,834,842) as applied to Claims 2 and 34, and further in view of Reynolds (US 5,904,827).**

Discussion of Tzanavaras et al., Downes et al., Langner et al., and Reynolds et al.

Please see a discussion of the combination of Tzanavaras et al., Downes et al, and Langner et al. in **Issue 2** above. Also, please see a combination of Tzanavaras et al., Downes et al., and Reynolds et al. in **Issue 3** above.

Appellant hereby repeats and incorporates his arguments set forth in **Issue 2** above, regarding Claims 2, 7-9, 34-37, and 39-42. Appellant respectfully submits that Claim 10 depends from patentable Claim 2, and Claim 38 depends from patentable Claim 34, and, therefore, Claims 10 and 38 are also patentable over Tzanavaras et al. in view of Downes et al. and Langner et al., for at least the same reasons discussed in **Issue 2** above.

Furthermore, Reynolds et al. is merely (purportedly) relevant to the further limitation in Claims 10 and 38 of continuing the ultrasonic or megasonic vibrations to the substrate during at least a portion of the electroplating step: "*wherein step (b) is continued during at least a portion of steps (c) and (d).*" As such, the disclosure of Reynolds et al. has no effect on the arguments set forth above regarding Tzanavaras et al. in view of Downes et al., and further in view of Langner et al. Furthermore, Reynolds et al. does not teach or suggest using an ultrasonic or megasonic prewetting step, as required by Claims 10 and 38 of the invention.

Therefore, neither Tzanavaras et al., nor Downes et al, nor Langner et al., nor Reynolds et al., nor any proper combination thereof, discloses or suggests the methods of Claims 2 and 34, with the further limitation that the ultrasonic or megasonic vibrations to the substrate are continued during at least a portion of the electroplating step, as recited in Claims 10 and 38. In light of the above, Appellant respectfully submits that Claims 10 and 38 are patentable over Tzanavaras et al. in view of Downes et al., and further in view of Langner et al., and Reynolds et al.

Issue 5: **Whether Claim 43 is unpatentable under 35 U.S.C. § 103(a) over Tzanavaras et al. (US 5,421,987) in view of Downes, Jr. et al. (US 2002/0189637) and Langner et al. (US 4,834,842) as applied to Claims 39-42, and further in view of Reynolds (US 5,904,827).**

Discussion of Tzanavaras et al., Downes et al., Langner et al., and Reynolds et al.

Please see the discussion in **Issue 4** above.

Appellant hereby repeats and incorporates his arguments set forth above in **Issue 2**, regarding Claims 2, 7-9, 34-37, and 39-42. Appellant respectfully submits that Claim 43 depends from patentable Claim 39, and, therefore, Claims 43 is also patentable over Tzanavaras et al. in view of Downes et al. and Langner et al., for at least the same reasons discussed in **Issue 2** above.

Furthermore, Reynolds et al. is merely (purportedly) relevant to the further limitation in Claim 43 of continuing the ultrasonic or megasonic vibrations to the substrate during at least a portion of the electroplating step: "*wherein step (b) is continued during at least a portion of steps (c) and (d).*" As such, the disclosure of Reynolds et al. has no effect on the arguments set forth above regarding Tzanavaras et al. in view of Downes et al., and further in view of Langner et al. Furthermore, Reynolds et al. does not teach or suggest using an ultrasonic or megasonic prewetting step, as required by Claim 43 of the invention.

Therefore, neither Tzanavaras et al., nor Downes et al, nor Langner et al., nor Reynolds et al., nor any proper combination thereof, discloses or suggests the methods of Claims 2 and 34, with the further limitation that the ultrasonic or megasonic vibrations to the substrate are continued during at least a portion of the electroplating step, as recited in Claim 43. In light of the above, Appellant respectfully submits that Claim 43 is patentable over Tzanavaras et al. in view of Downes et al., and further in view of Langner et al., and Reynolds et al.

Claim 39 Interpretation

In his latest Office Action (of 09/05/2007), the Examiner stated (on pg. 2):

> In order to set forth the proper metes and bounds of new claim 39, a certain amount of interpretation is required. Since claim 39 requires that wetting of the inside surfaces of the at least one opening is done by steps (a) and (b) alone, it specifically excludes an instance where the wetting of the inside surfaces is performed by immersing the substrate in any liquid other than the electrolyte. Thus, claim 39 cannot cover a process where (s) the substrate is immersed in an activation or wetting solution, (b) having ultrasonic or megasonic vibrations applied, then (a) immersing the substrate in the electrolyte, since such a process would include a process step (s) which wetted the inside surfaces other than steps (a) and (b).

Appellant respectfully submits that Claim 39 includes the instances where (i) the electrolyte is contained in an electroplating chamber, and the ultrasonic or megasonic step is performed in the electroplating chamber, and (ii) a separate chamber is used for steps (a) and (b): "*(a) immersing the substrate in an electrolyte, said electrolyte comprising metallic ions of said metal or alloy and at least one inhibitor additive; (b) applying ultrasonic or megasonic vibrations to the substrate;*" and, after step (b), transferring the substrate (with inside surfaces wetted by the electrolyte) to an electroplating chamber (containing electrolyte) to perform steps (c) and (d): "*(c) agitating the electrolyte across the front surface of the substrate; and (d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening; wherein inside surfaces of the at least one opening are wetted by utilizing steps (a) and (b) alone.*"

SUMMARY

In light of all of the above, Appellant respectfully submits that claims 1-10, and 29-43 are patentable. Accordingly, Appellant respectfully requests that the Examiner's rejections be reversed, and the application be allowed at the earliest opportunity.

Respectfully submitted,

Date: March 7, 2008

By

Uri Cohen
(650) 494-0268
4147 Dake Avenue
Palo Alto, California 94306

(8) **Claims Appendix.**

Copy of Claims 1-10, and 29-43 Involved in the Appeal

1. A method for electrofilling a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of:

(a) immersing the substrate in an activation or wetting solution;

(b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b):

(c) applying high pressure jets of an electrolyte to the substrate, said electrolyte comprises metallic ions of said metal or alloy; and

(d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening;

wherein the activation or wetting solution is the same as the electrolyte, and wherein steps (a), (b), (c), and (d) are performed in the same chamber.

2. The method of claim 1 wherein the electrolyte comprises at least one inhibitor additive.

3. The method of claim 1 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising a non-metallic surface.

4. The method of claim 1 wherein the at least one opening has a sidewall surface comprising an exposed metallic surface.

5. The method of claim 1 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface.

6. The method of claim 1 wherein step (b) is continued during at least a portion of steps (c) and (d).

7. The method of claim 2 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising a non-metallic surface.

8. The method of claim 2 wherein the at least one opening has a sidewall surface comprising an exposed metallic surface.

9. The method of claim 2 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface.

10. The method of claim 2 wherein step (b) is continued during at least a portion of steps (c) and (d).

11 - 28. Cancelled Claims **11-28**.

29. A method for electroplating a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of:

(a) immersing the substrate in an electrolyte contained in an electroplating chamber, said electrolyte comprising metallic ions of said metal or alloy;

(b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b):

(c) producing turbulent flow of the electrolyte at a surface of the substrate; and

(d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening;

wherein steps (a), (b), (c), and (d) are performed in the electroplating chamber.

30. The method of claim 29 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising a non-metallic surface.

31. The method of claim 29 wherein the at least one opening has a sidewall surface comprising an exposed metallic surface.

32. The method of claim 29 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface.

33. The method of claim 29 wherein step (b) is continued during at least a portion of steps (c) and (d).

34. The method of claim 29 wherein the electrolyte comprises at least one inhibitor additive.

35. The method of claim 34 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising a non-metallic surface.

36. The method of claim 34 wherein the at least one opening has a sidewall surface comprising an exposed metallic surface.

37. The method of claim 34 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface.

38. The method of claim 34 wherein step (b) is continued during at least a portion of steps (c) and (d).

39. A method for electroplating a metal or alloy inside at least one opening surrounded by a field on a front surface of a substrate, wherein at least one surface inside the at least one opening comprises an exposed metallic surface, said method comprising steps of:

(a) immersing the substrate in an electrolyte, said electrolyte comprising metallic ions of said metal or alloy and at least one inhibitor additive;

(b) applying ultrasonic or megasonic vibrations to the substrate; and after commencing step (b):

(c) agitating the electrolyte across the front surface of the substrate; and

(d) applying an electroplating current to the substrate to electroplate said metal or alloy inside the at least one opening;

wherein inside surfaces of the at least one opening are wetted by utilizing steps (a) and (b) alone.

40. The method of claim 39 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising a non-metallic surface.

41. The method of claim 39 wherein the at least one opening has a sidewall surface comprising an exposed metallic surface.

42. The method of claim 39 wherein the at least one opening has a bottom surface comprising an exposed metallic surface, and a sidewall surface comprising an exposed metallic surface.

43. The method of claim 39 wherein step (b) is continued during at least a portion of steps (c) and (d).

(9) <u>Evidence Appendix.</u>

See attached pages B1-B6.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Uri Cohen Confirmation No. 2289

Serial No.: 10/688,333 Filed: 10/17/2003

Grp. Art Unit: 1742 Examiner: Wilkins III, Harry D.

Title of Application: Methods and Apparatus for Activating Openings for Jets Plating

CERTIFICATE OF MAILING under 37 C.F.R. 1.8(a)

I hereby certify that this correspondence is being deposited on December 19, 2006 with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Uri Cohen, Applicant

December 19, 2006
Date of Signature

Mail Stop Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Declaration Submitting Evidence Under 37 CFR 1.132

1. I, Uri Cohen reside at 4147 Dake Avenue, Palo Alto, California 94306, am the inventor of the inventions disclosed in a patent application having Serial No. 10/688,333, which patent application was filed on October 17, 2003 and which patent application has a priority date of November 5, 2002, and I declare the following:

2. Prior to the priority date, I carried out experiments concerning jets electrofilling of very deep (30-95μm), blind vias in substrates with copper metal.

3. I obtained from a Japanese Consortium several 200 mm silicon wafers which included die patterns. Each die pattern consisted of several arrays of (mostly) square, blind vias which were etched into the 200 mm silicon wafers to provide vias having different widths, depths, and aspect ratios. The top surface of the wafers, including the sidewalls and bottom surfaces of the vias, were coated with a sputter-deposited, copper seed layer (before I obtained the wafers).

B1

4. I created the substrates by cutting pieces from the silicon wafers --each piece included roughly one die pattern. Next, the pieces were jets-electroplated with copper. Figures 1A and 1B show typical portions of arrays of 15μm wide (Figure 1A) and 50μm wide (Figure 1B) square vias after copper jets-electroplating --Figures 1A and 1B (in Exhibit A) are scanning electron microscope (SEM) photographs taken by Riga Analytical Laboratory ("Riga") at a 30°tilt angle to the top surface of a substrate. These photographs show both the top surface and a (cleaved) cross-section surface of the substrate.

5. The jets-electroplating experiments were carried out in a jets-electroplating cell similar to the one shown in Figure 1 of the present patent application. The acidic copper electrolyte consisted of 10% (v/v) H_2SO_4, 0.3 M $CuSO_4$, 50 ppm Cl^- ions, and two commercial additives ("Ultra Fill") supplied by Shipley Company. The jets pressure was 40 psi, the flow rate was 3.8 GPM, the anodes/jets assembly was rotated at 20 RPM, and the bath temperature was about 25°C.

6. I have attached, as Figures 2A-2D (in Exhibit A), four (4) SEM photographs of (cleaved, epoxy mounted, and polished) cross-sections of sample #192 which I electroplated in one experiment. This (cut piece or die) sample was: (a) pre-activated for 2 minutes in a slowly agitated 10% (v/v) sulfuric acid; (b) rinsed in deionized water; (c) dried; and (d) activated again for two (2) minutes in jets of the acidic copper electrolyte (in the jets-electroplating chamber) prior to commencing the jets-electroplating. The sample was then jets-electroplated at a (nominal) current density of 30 mA/cm^2 for 30 minutes, rinsed in deionized water, and dried. I then took the sample to Riga where the sample was cleaved, mounted in an epoxy mold, and polished. Riga then took SEM photographs of the mounted and polished cross-sections. Observations of several SEM photographs (Figs. 2A-2D in Exhibit A) of sample #192, provided the following data which is displayed in Table I below: via dimensions (width, depth, and aspect ratio), along with the observed wetting (or penetration) depth of the electrolyte (determined by the extent of plating on the sidewalls from the top, and indicated by horizontal arrows in the figures), and the fraction (in %) of the penetration depth relative to the total depth of the vias.

B2

Table I

Figure	Via Width (μm)	Via Depth (μm)	Via Aspect-Ratio	Wetting Depth (μm)	Wetted Depth Fraction (%)
2A	55	93	1.69:1	44.3	48
2B	17	74	4.35:1	37.2	50
2C	9	52	5.78:1	45.0	~87
2D	6	52	8.67:1	52.0	~100

7. As a result of those experiments (see Figs. 1A-1B and 2A-2D), I discovered that the very deep blind vias failed to be filled properly with electroplated copper. However, after I further examined the results presented in Table I, I discovered, unexpectedly and surprisingly, that the extent of electrolyte penetration and plating into the blind vias (see column 5 in Table I, and the horizontal arrows in Figs. 2A-2D) was better in the narrower and higher aspect ratio vias than in the wider and lower aspect ratio vias (see column 2 in Table I). In addition, I discovered that the difference between the results for narrower vias and wider vias was even more apparent when the wetted depth (from the top) was considered as a fraction of the entire depth of the vias (see column 6 in Table I).

8. My conclusions from the above data are: (a) the extent of wetting inside narrower and higher aspect ratio deep openings is further and better than in wider and lower aspect ratio openings, and (b) the lack of wetting inside the wider and lower aspect ratio deep openings is likely due to insufficient capillary forces.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

12/19/2006
Dated

Uri Cohen, Applicant

Attachment: Exhibit A consisting of six (6) SEM photographs.

Exhibit A

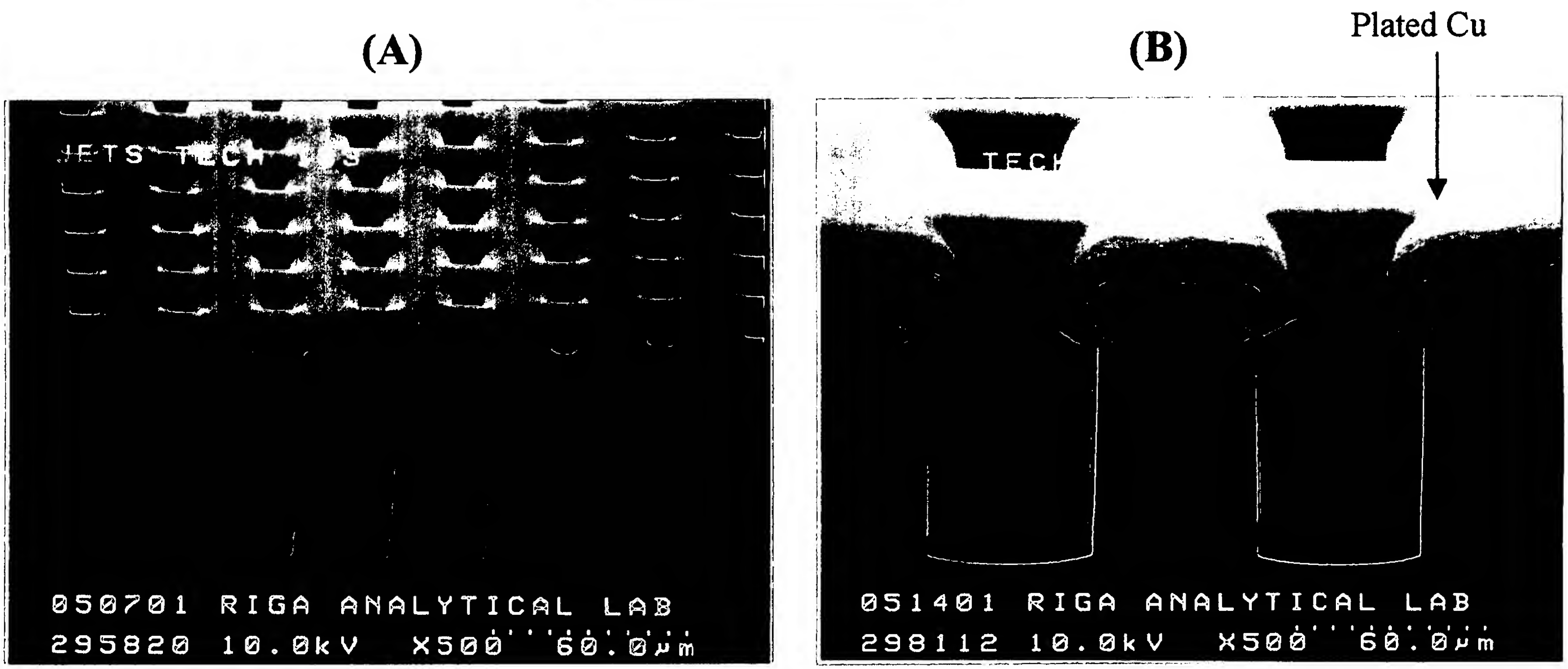


Fig. 1 SEM photos (30° tilt) of cleaved cross-sections after copper jets electroplating, showing both top and cleaved surfaces; Horizontal arrows indicate extent of wetting: (A) 15μm wide square blind vias, and (B) 50μm wide square blind vias.

Exhibit A

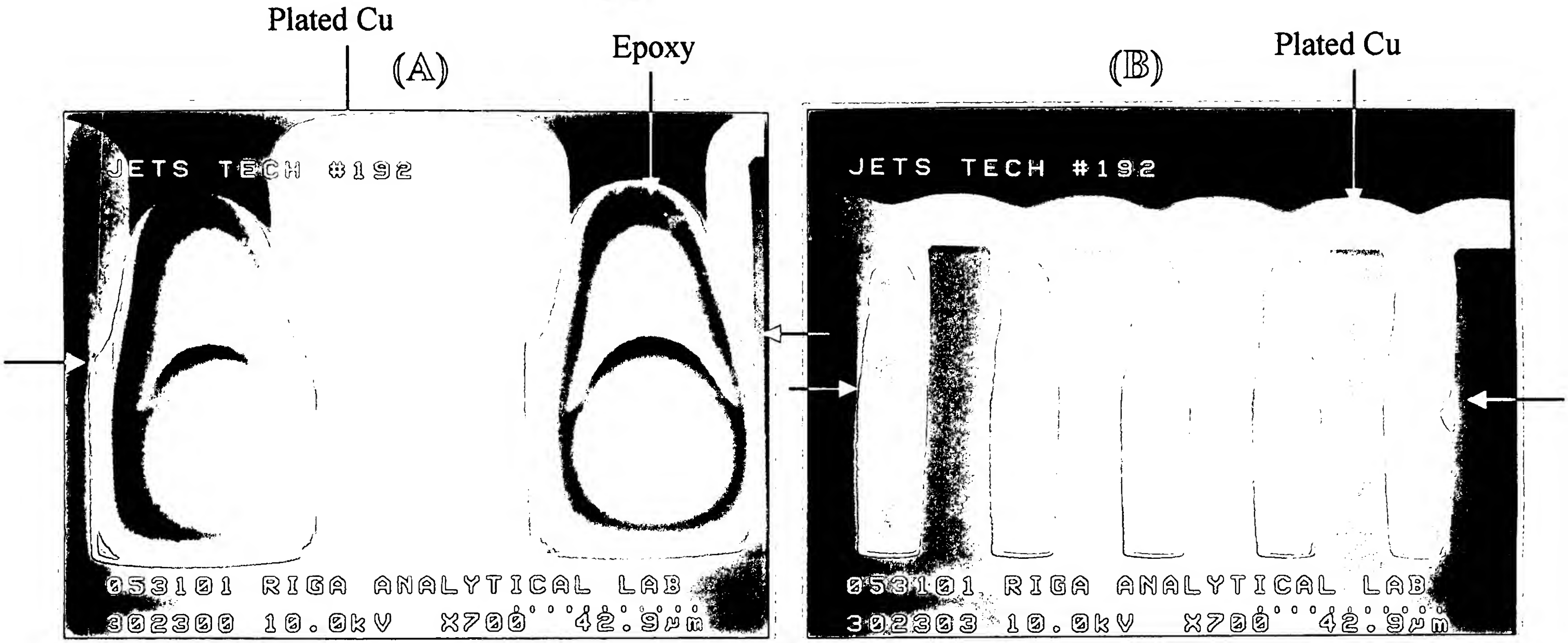


Fig. 2 SEM photos of cleaved cross-sections after copper jets electroplating showing only cleaved surface; Horizontal arrows indicate extent of wetting: (A) 55μm wide square blind vias (epoxy was used for mounting and polishing), and (B) 17μm wide square blind vias.

B5

Exhibit A

(C) Plated Cu (D) Plated Cu

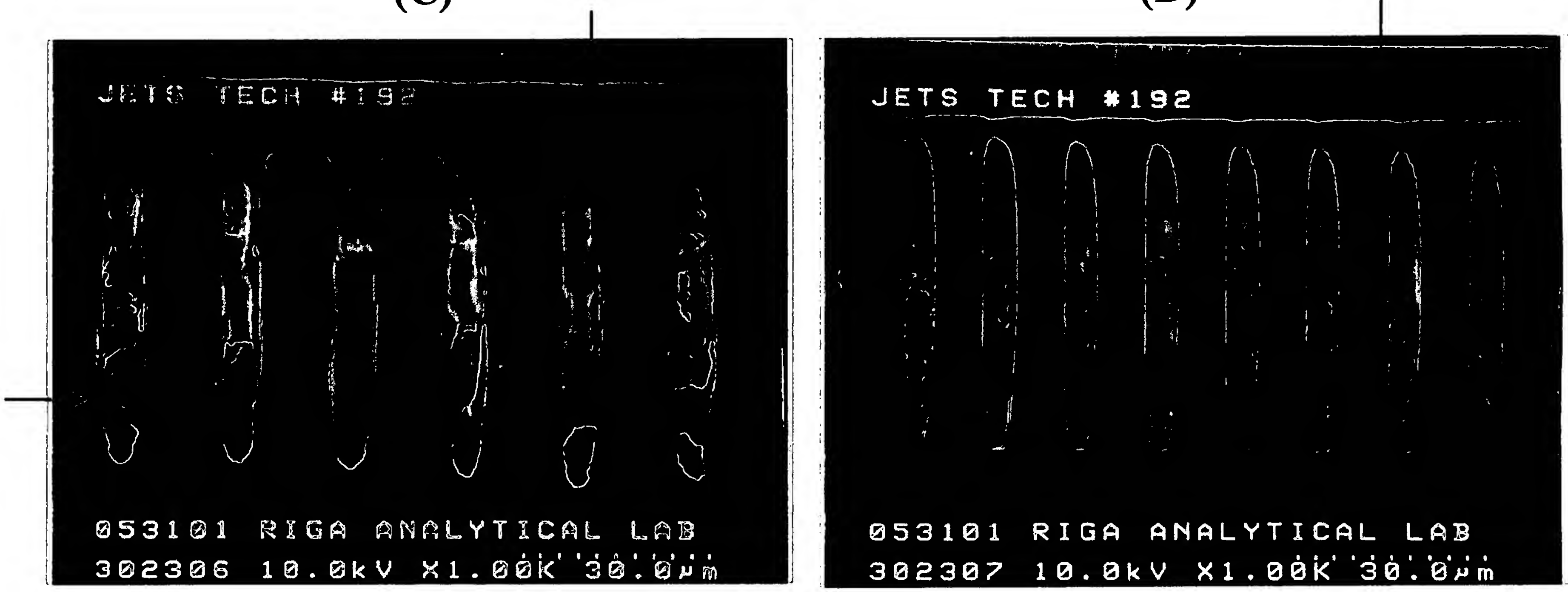


Fig. 2 (continued) SEM photos of cleaved cross-sections after copper jets electroplating showing only cleaved surface; Horizontal arrows indicate extent of wetting: (C) 9µm wide square blind vias, and (D) 6µm wide square blind vias.

B6

(10) Related Proceedings Appendix.

None.